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Labour Mobility and Innovation Activities of the Firm

Master's thesis

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I have written this master's thesis independently. All viewpoints of other authors, literary sources and data from elsewhere used for writing this paper have been referenced.

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Abstract I investigate the linkage between labour mobility and innovation activities of the firm using merged data set from CIS survey and the Estonian employer-employee data on payroll tax payments of Tax and Customs Office for 2008-2010 years. Applying CDM model, I find that the positive linkage between mobility of new employees from sending firms with process innovation and probability of having product innovation in the receiving firm. But the probability of having process innovation in the receiving firm is positively associated with the labour mobility of new employees from firms with both process and product innovation.

Keywords Labour mobility; Innovation; Firm Level

1. Introduction

In 2003 Estonian IT specialists Ahti Heinla, Priit Kasesalu and Jaan Tallinn developed the backend for innovative start-up Skype Technologies that very soon became one of the most popular video-call services in Estonia and worldwide. On 10th of May 2011 Skype was purchased by Microsoft for $8.5 billion in its biggest ever cash deal. But all of this was not possible without the founders of Skype the Swede Niklas Zennström and the Dane Janus Friis. Firstly, the owners themselves move from one job to another. And secondly, hiring new employees made possible to create the innovation for video-call service. What is the conclusion we may do? In this story labour mobility is the key-factor of success.

The main aim of my research work is to determine the linkages between inter-firm labour mobility and innovation activities of the innovative firms based on the Estonian sample. To manage the assigned task I will do the following steps. First, I would like to introduce theoretical background and mechanism for the effect of labour movement on innovation output. Second, I support the theory by empirical investigations and expect to find evidence on positive association between inter-firm labour flows and recipient firm's innovation activity. Third, I will make general conclusions based on both empirical and theoretical parts and provide a discussion about obtained results.

While much of the previous literature concentrate on indirect measurement for labour flows as churning rate and qualitative indicators for innovations, such as number of patents,research papers, prizes, invention disclosures, and degrees awarded, my study following the other studies using matched employer-employee data (e.g. Maliranta et al. 2008, Moen 2005) explores the linkage between labour mobility and innovations directly. This topic seems to be underestimated especially for Nordic economies, including Estonia[1].

To investigate the question of innovations in Estonia, I consider statistics based on Community Innovation Survey (CIS) data, which is reliable and widely used dataset for this kind of study. At the same time, the labour mobility is disclosed according to the

[1] According to Eurostat data, in 2015 Estonia spends more than 1.5% of GDP on research and development. Moreover, around 75% of total workforce is active in Estonia. These two numbers may speak about importance of labour and innovations issue for this country.

dataset on firm and individual level pay-roll tax payments, obtained from Republic of Estonia Tax and Customs Board. Thus, I am able to analyze labour mobility and its effect on innovations directly, but not through the knowledge spillovers and productivity and competiveness as it was done in most studies before (Müller and Peters 2010).

Overall, labour mobility could influence innovation output through three main channels. Firstly, labour mobility could be considered as a mechanism of knowledge diffusion and, thus, be a strong channel for potential spillovers (Arrow 1962, Stephan 1996). Hence, "knowledge spillovers occur when a firm's R&D project discloses new information that is useful to another firm in its R&D efforts, and the emitting firm is not fully compensated for the input."(Maliranta et al. 2008, page 5). Two types of knowledge spillovers are identified. Marshall developed and Arrow and Romer extended later the theory of spillovers that are known as MAR spillovers by the first letters of the last names of its inventors. It occurs in the same industry and it pushes firms of the same industry to be located close to each other in some area. Examples for this type of spillovers are Silicon Valley for IT industry and Los Angeles for movie industry. Second type of spillovers is called Jacob spillovers (Jacob 1969). In contrast with MAR spillovers, Jacob spillover occurs among people with different background and, thus, working in different industries.

Secondly, labour could be considered as one of the most important inputs in production for every good and process, especially for innovation. Thus, increasing the labour mobility probably means also increasing input for innovation creation process. According to Guo (2008), the increase in innovation input leads to significant growth of innovation output or the higher probability for innovation output creation output.

Thirdly, inter firm labour mobility could be considered not only as source of knowledge spillovers, but also as communication channel, that could be formal and informal way for information sharing. While in formal way of sharing knowledge various ways for sharing knowledge electronically are used, different conferences and scientific meetings provide useful and effective informal method for transferring experience and could be considered as important sources of new ideas [2]. Thus, communication with other colleagues could inspire to start new innovation projects or help to find a new solution for existing problems and unsolved questions in current research. Also in such meetings or conferences it is possible not only to learn about new streams in innovation field, but also to find new personnel for own projects. The only difference between knowledge spillovers and communication spillovers is whether the effect on final innovation output is direct or indirect.

As I use micro-level data, this research will be useful also from the management perspective. If certain rate of labour mobility increases innovation output that creates some benefits for the firm, then human resource department should pay close attention to this fact and manage it by trying to achieve optimal rates of hiring and firing process. As I study an important and topical issue for Estonia, my research is likewise interesting for policy-makers. In 2010 EU members passed Europe 2020 plan of development that is a ten-year strategy for development and growth. Particularly, the Union has set five main objectives and innovation is among them. If the success of innovation activities is positively associated with labour mobility, then supporting the process of mobility of work force may contribute towards meeting the targets set by EU. Also my study may be interesting for scientists as it will show them the importance of the effort of every specialist for creating innovative goods, service and process, and it will allow understanding that the mobility of every specialist matters.

The structure of the rest of the paper is the following. In second section the main theoretical concepts for labour mobility and innovations are presented to understand the basics of the theoretical part of this study. In third section literature overview is given to explain the current views and opinions on linkage between labour mobility and innovations. In empirical part in section four the description of used dataset with descriptive statistics is given and the applied econometric model is introduced. The main results are presented in section five. The final section concludes.

[2] For example, Stephan (1996) investigates geographical labour mobility as communication channel of biotechnology companies and university-based scientists, based on 54 firms and 445 universities in different states of USA. Author makes the conclusion that around 70% of links between companies and universities are non-local. The studies by Audretsch and Feldman (1996) imply that in informal way of knowledge transfer geographical proximity is important.

1. Labour mobility and innovation: theoretical background

Inter-firm labour mobility provides a strong channel for knowledge exchange as skills and experience are highly embodied in human beeings. Thus, people use knowledge for producing innovations, thereby, ensuring sustainable growth for economies.

In general sense labour mobility is a movement of workforce that could occur in different ways. Changes in job of worker could be related with movements across different geographical regions or countries (geographical mobility) or include shifts in duties (occupational mobility) (Long, Ferrie 2011). Occupational mobility could occur inside the firm. In such case a worker switches from one position to another without changing the employer. A worker may also make the decision to switch from one firm to another and in such cases we are speaking about inter-firm labour mobility.

Labour mobility could be temporary or permanent process. Both types of labour mobility matter for innovations. If professional or scientist changes his or her job permanently, then we may speak about “brain drain” process. Receiving country or firm obtain skilled specialist without any costs for his or her education or training. Nevertheless, new employer benefits from knowledge by increasing the innovative output. For sending firm it could be damaging to lose such worker because part of knowledge, embodied in individual, leaves with this specialist. Moreover, potentially firm’s productivity could fall down in the short-term due to such loss of workforce. Another case is posting process that is permanent movement for job or training. A posted worker is an employee who is sent by his employer to carry out a service in another EU Member State or firm within one EU state on a temporary basis (Meier 2004). For Estonia 2.2% of total workforce is posted workers. Especially, this type of job-mobility is inherent in construction and IT sector as providing service for developing new soft-ware. In this case we do not have losing firm and the innovation output may increase in both firms.

Another aspect of labour mobility is the fact that movements from job to job are made by workers with different skills and knowledge. Cappelli (1999) investigates the careers of workers with different qualifications and concludes that those, who don’t have constraints to mobility and have good management skills, are usually more successful in their career. As a rule, worker with better education and longer job experience knows the labour market of his/her region or country rather well. Thus, he or she is better informed about possibilities and the rate of migration among high-skilled professionals theoretically should be higher than for low-skilled. However, for the economy the mobility of skilled labour could be constrained by the lack of jobs for highly qualified specialists. From another side, low-skilled job doesn't mean no-skills job (Almeda and Kogut 1999). Many of these skills can only be obtained through schooling or on-the-job training. That is why workers lacking skills find it difficult to attain a foothold in the labour market.

One may think that the mobility of high skilled professionals could be more important than the mobility of low-skilled workers who are not directly involved in innovation process as the correlation between the effort of low-skilled worker and company's final innovation output is weaker than that between the effort of high-skilled worker and innovation output. However, firing of worker who is not scientist or inventor could still damage the whole innovation process. For example, Moen (2005) investigates the mobility of technical staff in R&D incentive firms. He pointed to the significant role of supportive workers based on example of technical staff. According to his findings, workers that are not directly related with research work are able to accumulate knowledge over time that is reflected in increase of their wages. Using obtained knowledge they become more significant in innovation process.

However, the rate of labour mobility and its effect on total productivity varies from one sector to another. Pacceli et al. (1998) find that the rate of labour mobility is higher among innovative sectors than traditional sectors, and higher among non-manual workers as compared to the manual workers. The study by Lenzi (2006) considers mobility of high-skilled works as one of the most influential channels for knowledge transmission and concludes that the most innovative workers are the most likely to move.

Firm could not only benefit from incoming spillovers, but at the same time also lose some information as the result of knowledge outflow. The main feature of information is that the large part of the knowledge that is used in the innovation process is tacit and cannot be protected e.g. by patents. Moreover, hiring new R&D worker causes high transaction costs. Hiring new R&D workers could be costly from one hand and time-consuming on the other hand due to length of recruiting and training processes. Thus, firm may suffer from high volatility among its R&D workforce. The u-shaped relation between mobility and innovativeness implied by these opposite effects was found in studies by Müller and Peters (2010) and Ettlie (1985).

At the industry level high mobility among R&D employees may lead to underinvestment in innovations. Lenzi (2006) pointed out that the former employer may move to labour market or join a new firm that could be the competitor, and exploit the research results. Thus, labour mobility increases the risk for innovation activities of firm and that causes underinvestement in innovative activities.

Firms could prevent the loss of information in the following way. First, an optimal informational structure reduces both the possibility of information, and hence, profit, lost and decreases the potential gain to the receiving firm (Feinstein and Stein 1988, Trebilcock 1985). Second way to reduce the loss for the donor firm is to attempt to acquire property rights over patentable information, however, in reality it doesn't work in a proper way as not all the information is patentable and this feature of information makes it "extremely difficult to distinguish between theft and independent discovery" (Cheung, (1982) page 17). The last way to prevent the loss of the innovation information with labour-mobility is to use non-compete and non-disclosure labour agreements (Pakes and Nitzan 1983).

2. Review of the empirical studies on linkages between labour mobility and innovation

The topic of labour mobility seems to be well investigated. There are more than hundred papers related to the topic of labour mobility[3] and its positive linkage with firm productivity[4]. Furthermore, there are dozens of investigations, concerning labour mobility and innovations[5]. Some of the relevant papers are presented in Appendix 1.

[3] See for example Arrow (1962), Burgess (2000), Breschi and Lissoni (2001), Power and Lundmark (2004), Moen (2005), Hoisl (2007), Aoshima (2008)
[4] See for example Martins (2005),Parrotta and Pozolli (2012), Poschl and Foster (2013), Poole (2013)
[5] See for example Pacelli (1998), McCann and Simonen (2005), Almeda and Kogut (1999)

Although the empirical part is based on specific Estonian sample, theoretical background falls back on several basic articles, those give understanding of labour mobility theory and principals of innovation activities, see Jovanovic (1979) and Cooper (2001). According to these theories, labour mobility provides matching between employers and employees. This is very crucial process as only under perfect matching firms are able to maximize profits, and workers have an opportunity to get most out of their skills to maximize their wages. Nevertheless, only after some period of time from hiring the worker, firm may learn about the quality of the job match. If a job matching is poor, then the productivity of the worker will be low, and firm has to decide whether to keep the worker or to fire. Thus, labour mobility provides the channel of finding higher quality skills and may improve the level of matching between the employee and the firm. Pakes and Nitzan (1983) provide the theoretical model, where firms are free to hire scientists and research personnel and choose the type of contract for each employee. Pakes and Nitzan conclude that labour mobility does not reduce the profit of the firm, since under such conditions of free choice firm is able to dismiss a scientist, who was not capable to perform the task of employer.

Moreover, higher mobility generally causes the increase in technological progress, due to non-rivalry of knowledge. In other words, different firms may use the same knowledge simultaneously. As the result of this approach both the donor firm and the receiving firm may benefit from the knowledge exchange. Thereby, labour mobility results in the net increase in innovation output of both firms and, unlike the traditional reasoning, stimulate the R&D investments. Therefore, according to Cooper (2001), the correct strategy for any firm will be investing in training even if the high mobility is expected in the future.

Growth in developed countries depends mainly on technological innovation, and empirically this fact is proven given demonstrated positive linkage between innovation and productivity at the firm-level for most of the countries (Raffo et. al. 2008, Mairesse and Mohnen 2002). As an example of developed countries, the survey-data about firms located in Germany is examined in Müller and Peters (2010) paper. Authors show the role of churning among R&D worker for the innovation output based on the survey-data about firms located in Germany. In the paper various types of innovation are distinguished such as process and product innovation. The found the linkage between labour mobility and innovation performance to be positive, but only up to some threshold of the labour mobility. At the same time, for Finland Maliranta et al. (2008) investigated employer-employee panel data and found quite strong evidence that hiring workers from another company's R&D department doesn't increase the productivity of the receiving firm, but placing researchers in non-research department could boost both productivity and profitability.

Tambe and Hitt (2014) obtain similar results for USA. They consider labour mobility in IT sector. One of the distinctive features' of IT-related innovations is the high rate of using know-how technologies and work experience that are embodied in human capital. Thus, the moving of high-skilled workforce should influence IT industry much more compared with traditional sectors of the economy. After analysis of 10 million resumes, authors suggest that "firms derive significant productivity benefits from the IT investment of other firms from which they hire IT labour" (page 5). Moreover firms, located close to region of high concentration of IT activities, where the high-tech investment should be also high, may receive substantial economic benefits from the mobility of technical workers.

In case of Estonia, the survey-data is investigated considering the topics for labour mobility and innovations. For instance, Kurik et al. (2002) state that research and development employees become more and more important for the Estonian economy. Masso et al. (2011) use Estonian database from online job search portal that includes detailed information about former occupations for an employee as information on labour mobility, and match this data with 3 waves of Community Innovation Survey data (from 1998 to 2006) as the source of the innovation data. They provide evidence that higher worker mobility is associated with higher probability of product innovation by the recipient firm. For Estonian enterprises, more innovation input leads to higher probability of having innovation output (Masso and Vahter 2008) and innovations are positively correlated with higher productivity (Vahter 2006). These conclusions are in accordance with studies for other countries.

4 Empirical Analyses

4.1 The Data and descriptive statistics

The empirical analysis is based on two datasets. Community Innovation Survey (CIS) is used for determining innovativeness of the firm and factors that are linked with it. This dataset is widely used in earlier papers related to innovativeness and productivity on the firm level, e.g. see Müller and Peters (2010) for Germany, Masso and Vahter (2011) for Estonia, Griffin et al. (2006) for France, Germany, Spain and UK. Each wave of the survey includes the general background related to the company's activities such as number of employees, the form of ownership, participation in exporting and volume and presence of innovation activities. The target population consists of Estonian firms having at least 10 employees and refer to manufacturing, mining or service sectors according to the Estonian Classification of Economic Activities (EMTAK). The survey methodology and definitions of innovativeness are related with pan-European Oslo Manual and therefore ensure comparability of innovation surveys across all EU.

Information about labour mobility is obtained from the Estonian employer-employee data on payroll tax payments of Tax and Customs Office that contains information about age, gender and wage level of personnel for the period 2006-2014. Thus, using firm's unique registry code it is also possible to identify both receiving and sending firm in case of labour mobility of the employee. Therefore, we can follow also the way from initial sector to the next one in case of cross sectoral job-mobility. This dataset has been previously used in earlier studies (Masso et al. 2015).

The CIS survey includes 7 waves for Estonia at the moment (Spring 2017) but in this study I use only 3 of them: CIS2006 (2004-2006), CIS2008 (2008-2010) and CIS2010 (2010-2012) as I matched innovation data with labour mobility data that starts from 2006. The wave of CIS2006 determines the innovativeness of the recipient firm in case of labour mobility and two last waves, these are CIS2008 and CIS2010, are used for final estimation of the linkages between labour mobility and innovation. As the innovation output variables following Ettie (1985) product and process innovations are considered. According to the Oslo Manual, product or process innovators are firms that successfully introduced new product or process during 3 previous years. A product or process innovation is defined as a new or significantly improved product or process in comparison with existing products or processes on the market. Definitions and descriptive statistics of the main variables are reported in Appendix 2 in Appendix 3.

Thus, in the merged innovation activities- labour mobility data set, innovation activities variable takes the value 0 in case of absence or 1 in case of presence of innovation expenditures. A use of the dummy variable for innovativeness measurement is in accordance with earlier papers (Griffith et al. (2006)). Alternatively the number of patents (Lööf et al. (2006), Kaiser et al. (2008)) or R&D expenditure per employeeor the share of innovative products in sales Fcan be used. However, for Estonia number of patents could not fully reflect the innovation activity as vast majority of the firms (for example, especially small ones) do not use patenting for their innovations as it is too costly.

At the same time labour mobility variables are measured directly as flows of employees from one job to another. Due to the shortage of data, I am not able to distinguish directly the position of the worker. However, following to Mion and Ortomolla (2014) labour mobility of managers and top-specialists is one of the key factors of innovation activities, thus, it could be crucial for results. Moreover, according to study of Rao et al. (2002), skills and experience of employees are drivers of innovation dynamics, thus, for the purpose of this research it could be also useful to clarify the skills level of moving employees. Thereby, based on the wage level I attribute those who receive wage belonging to the upper 20% of the wage distribution of the industry, to high skilled employees who manage the product or process innovation. If the company does not have a manager based on the above condition, then the employee who receives the highest salary for the company is considered to be a manager. The determination of employee's skills and position based on the wage level can be found earlier studies; see for example Masso et al. (2015), and Masso, Vahter (2016).

Still such classification could cause the selection problem. Firstly, non-managers could be considered as managers and, secondly, one could argue that wage level do not fully reflect the skills level. In the case of country like Estonia that problem could be relatively small because as compared to countries with more compressed wage distribution like Sweden due to high wage inequality managers are usually paid a lot more than non-managers. For example, in 2010 the wage gap between managers and the lowest paid occupational group was 3.1 times (Masso et al. 2015). In the second case, assuming that employee, who receives high wage, has also high level of skills is based on the following. High salary of the employee reflects the experience and education level that is in fact could be considered as return on cost for getting this education and experience. Thus, high wage also could be considered as proxy for high skills. Thus, I proxy high wage as signal of employees having management occupation and high skills level, an as we argue it should cause only relatively small errors in estimation.

As it was pointed in literature review for Jacob and MAR spillovers, one of the most crucial factors in the linkage between labour mobility and innovations is the similarity of receiving and sending sectors. Thus, receiving firm could refer to the same sector as sending one or could differ. Depending on the sector, the innovative experience the employee has could be more or less applicable for the receiving firm. Following study of Dekle (2002) who investigate Japanese prefectural data and conclude strong MAR externalities especially for service sector, I also look separately on flows where the receiving and sending firms are in the same sector.

The preliminary data analysis of labour mobility of managers with different wage levels and innovation activities are shown in Table 1. As it was said before, I consider that wages reflect skills level. Manager who receives higher wage obtains more valuable experience or education and, thus, the mobility of higher skilled workers could be strongly associated with innovation activities of the receiving firm. Table 1 presents the linkage how innovation activities vary for firms with new managers with different skills level based on their wage level within and across sector. If we consider that either receiving or sending firm is process or product innovator, then the mobility of managers could be linked with higher innovation activities. However, there is very weak evidence that managers with wages in the upper 10% of the wage distribution are connected more strongly with innovativeness of the receiving firm than managers receiving wages belonging to the upper 20% of the wage distribution.

According to the Table 1 it is possible to conclude that more managers tend to change their job positions between noninnovative firms to noninnovative firms of different sectors. If we consider the mobility of managers from innovative firms, then about

0.18% of managers move to noninnovative firm for the same 2 dig.sector and about 0.2% for the same 3dig.sector. Overall the highest rate of mobility is between noninnovative firms of different sectors.

Table 1. Mobility of managers and innovation activities, in percentage.

Sector	**Sending firm**	**Receiving firm**	**All employees**	**Managers (based on upper 20% of wages)**	**Managers (based on upper 10% of wages)**
Same 2-dig. sector	Innovative	Innovative	0.037	0.012	0.011
	Innovative	Noninnovative	0.257	0.184	0.187
	Noninnovative	Innovative	0.254	0.223	0.224
	Noninnovative	Noninnovative	3.017	2.289	2.046
Other 2-dig. sector	Innovative	Innovative	0.089	0.028	0.03
	Innovative	Noninnovative	0.88	0.421	0.396
	Noninnovative	Innovative	0.583	0.264	0.263
	Noninnovative	Noninnovative	6.753	3.115	2.532
Same 3-dig. sector	Innovative	Innovative	0.031	0.015	0.034
	Innovative	Noninnovative	0.248	0.204	0.827
	Noninnovative	Innovative	0.354	0.343	0.132
	Noninnovative	Noninnovative	2.016	1.279	1.034
Other 3-dig. sector	Innovative	Innovative	0.093	0.034	0.036
	Innovative	Noninnovative	0.76	0.561	0.486
	Noninnovative	Innovative	0.463	0.283	0.364
	Noninnovative	Noninnovative	5.793	2.181	1.487

Moreover, in Table 2 I compare the mobility from different sectors of managers and other employees and its linkage to innovation activities. These numbers show that MAR spillovers could be strong factor and should be considered in further estimation especially for process innovation as the linkage of managers and other employees from the same industry is the strongest for process innovation. Moreover, it is more crucial factor for exporting and foreign firms in both product and process innovation. The Table 2 also suggests that the mobility of new managers or employees compared with "no mobility of new employees" could be linked with more frequent innovations of the firm.

Table 3 shows the estimation results from probit model for labour mobility of both managers and other employees from the same and different sector of receiving and sending firm. As it was suggested in Tables 1 and 2, the probability of having innovation activities of the recipient firm is linked positively with labour mobility of both managers and other employees.

Table 2. Mobility of managers and other employees from same and different sectors and innovations

Receiving firm	Process innovation (dummy)				Product innovation (dummy)			
	Exporting firm	Foreign firm	Process innovation (dummy)	Product innovation (dummy)	Exporting firm	Foreign firm	Process innovation (dummy)	Product innovation (dummy)
No new employees from innovative firms	0.125	0.166	0.193	0.203	0.184	0.221	0.202	0.211
New employees from innovative firms	0.365	0.381	0.397	0.41	0.3	0.304	0.32	0.326
New managers from innovative firms	0.42	0.435	0.483	0.486	0.332	0.343	0.372	0.377
New employees from innovative firms from the same industry	0.419	0.438	0.473	0.485	0.325	0.336	0.325	0.358
New managers from innovative firms from the same industry	0.469	0.46	0.54	0.562	0.341	0.325	0.349	0.423

Table 3. Labour mobility of managers and other employees and innovations in manufacturing and service sectors (Probit model)

	Process innovation (dummy)			Product innovation (dummy)		
New employees from firms	Total sample	Manufactoring sector	Service sector	Total sample	Manufactoring sector	Service sector
process innovation (dummy)	0.504	0.528	0.439	0.323	0.325	0.285
	(8.16)***	(6.36)***	(4.38)***	(5.21)***	(3.98)***	(2.85)***
process innovation from the same industry	0.455	0.429	0.444	0.253	0.143	0.419
	(8.65)***	(6.25)***	(4.90)***	(4.69)***	(2.04)**	(4.48)***
product innovation (dummy)	0.499	0.479	0.497	0.312	0.295	0.292
	(8.68)***	(6.27)***	(5.19)***	(5.39)***	(3.87)***	(3.04)***
product innovation from the same industry	0.451	0.387	0.499	0.366	0.232	0.525
	(8.12)***	(5.42)***	(5.21)***	(6.49)***	(3.20)***	(5.37)***
foreign firms (dummy)	0.538	0.483	0.648	0.214	0.151	0.351
	(6.97)***	(4.81)***	(4.79)***	(2.85)***	(1.58)	(2.71)***
foreign firms in the same industry (dummy)	0.225	0.267	0.189	0.136	0.135	0.126
	(4.33)***	(3.94)***	(2.14)**	(2.55)**	(1.94)*	(1.39)
New managers from firms						
process innovation (dummy)	0.518	0.511	0.502	0.349	0.292	0.426
	(10.11)***	(7.64)***	(5.67)***	(6.62)***	(4.30)***	(4.68)***
process innovation from the same industry	0.469	0.477	0.413	0.338	0.161	0.530
	(7.13)***	(5.47)***	(3.59)***	(5.02)***	(1.82)*	(4.45)***
product innovation (dummy)	0.484	0.425	0.510	0.354	0.292	0.431
	(9.34)***	(6.25)***	(5.69)***	(6.68)***	(4.25)***	(4.72)***
product innovation from the same industry	0.529	0.478	0.566	0.564	0.378	0.750
	(7.29)***	(4.96)***	(4.50)***	(7.72)***	(3.92)***	(5.77)***
foreign firms (dummy)	0.485	0.427	0.656	0.303	0.271	0.442
	(9.17)***	(6.26)***	(6.87)***	(5.62)***	(3.92)***	(4.62)***
foreign firms in the same industry (dummy)	0.267	0.312	0.216	0.131	0.057	0.167
	(4.45)***	(3.84)***	(2.19)**	(2.14)**	(0.69)	(1.62)
Number of observations	2932.000	1700.000	1004.000	2932.000	1700.000	1004.000

Note: Absolute values of z statistics parentheses *significant at 10%; ** significant at 5%; *** significant at 1%.

Thus, the result from Table 3 is in accordance with the study of Moen (2005) who argues about the importance for innovation of both types of workers. However, in case of probit model coefficients we can not interpret the coefficients directly as indicating causal relationship, but still we may see that the linkage of mobility of workers and innovation activities is positive and significant for all types of skills and experience of employees. Moreover it is also significant for both product and process innovation in both manufacturing and service sector. Thus, in final estimation all these independent variables from probit estimation should be considered as explanatory variables into regression.

Let us briefly summarize the results of the preliminary data analysis before proceeding to the descriptions of the model. First of all, the investigated data set include variables for innovation activities from CIS survey and payroll tax data for labour mobility. To match these two datasets the years 2008-2010 and 2010-2012 are used in the estimation of the regression models. Secondly, because of the data shortage I consider wage level as level of skills and job position of the worker and investigate the mobility of managers and other employees. From innovation side I distinguish between product and process innovations on the firms of manufacturing and service sectors. Thus, I consider the mobility of workers both within and across sector (the 2-digit industries). Such classification is supported by the previous literature studies and merged data set of my study. Thirdly, from probit estimation I found that all variables for labour mobility are significant and positively linked with innovation activities.

4.2 Econometric Model

I estimate the models over the sample of Estonian firms from 2008 till 2010 and 2010-2012 but only some of them (see descriptive statistics) make investment into innovations. But their decision not to innovate is connected with some circumstances (for example, lack of financial support or experience of innovation). Thus, those firms who are non-innovative are not random, but self-selected sample and that should be accounted for in the econometric model. In case if we exclude non-innovative sub-sample or replace it by zero`s we will probably over-estimate or under-estimate the labour movements in population of all firms. The solution is to use the CDM model.

This model is based on Crèpon, Duguet and Mairesse (1998) and widely used in literature (Mohnen et al. 2006, Griffin 2006).

It consists of the next decision stages: firms decide to engage or not to innovations; then firms consider how much support to put into innovation projects; as a result of innovation input firms get from knowledge production function innovation output (innovation product or process). For first stage estimation it is used Heckman sample selection model (Heckman 1976). On the second step bivariate probit model is applied.

The model takes the form of the following equations. First, we can include the latent (unobserved) variable that determines motivation to innovate (g_i^*)

$$g_i^* = \beta_0 x_{0i} + \varepsilon_{0i} \tag{1}$$

where g_i^*could be 0 if the firm is non-innovator and 1 if the firm makes innovation investment, x_{0i} is a vector of independent variables that determines the incentive to innovate and β_0 is the associated coefficient vector, ε_{0i} is the error term. Moreover the incentive to innovate or not depends on some other factors, for example, costs of innovation and expected profits from it. Thus, when g_i^* is larger than some threshold level, firm makes innovation expenditures. In other case the firm stays in the market as non- innovator.

On the second stage we observe the presence of innovation expenditures or its absence. The innovation expenditure, denoted as r_i^*., takes the values 0 if the firm does not innovate or 1 if the firm is involved in innovation. It can be given by the following equation:

$$r_i^* = \beta_1 x_{1i} + \varepsilon_{1i} \ if \ g_i = 1 \tag{2}$$

where x_{1i} is a vector of independent variables; β_1 is vector of associated coefficients and ε_{1i} is an error term that is jointly distributed with ε_{0i} from the (1) equation.

At the next step we estimate the linkage between two types of innovation and their determining variable; we define both types of innovation dummy variables, in particular for product and process innovation, according to the following formula:

$$t_i = \alpha_k r_i^* + \beta_2 x_{2i} + \varepsilon_{2i} \tag{3}$$

It should be noted that the equation (3) is bivariate probit estimation for process and product innovation dummies (Masso, Vahter 2008, Müller and Peters 2010) as it allows for two equations for product and process innovations with correlated disturbances ε_{2i} (Müller and Peters 2019). Bivariate estimation is used as in practice product and process innovation are found to be connected with each other. Also the term r_i^* that is unobserved intensity to innovate is included in equation (2) and (3) and basically solves the problem for selectivity and endogeneity.

4.3 Empirical results

Table 4 presents the results for estimation of innovation intensity and probability of innovation expenditures. Overall we may say that the results are in accordance with earlier findings in previous literature (Moen 2005, Griffith 2006, Müller and Peters 2010).

In model we observe that foreign ownership is not significant for innovation intensity in either manufacturing and service sector; however the probability of engaging in innovation is positively correlated with foreign ownership for service sector that is in accordance with earlier studies (Masso and Vahter 2011). If we consider the manufacturing sector of the economy, then for companies that carry out innovative activities, the participation in the international market positively related with innovation activities. Surprisingly, for the service sector, this factor is not significant. And this finding is contrary with study Masso and Vahter (2011) for service sector. On the one hand, such influence can also be explained in terms of the growth competition in international markets.

The significant positive linkage with innovation expenditure comes from public funding variables. Moreover, this result is also preserved for innovation intensity. Thus, we may conclude that the firm that has public funding is more likely to have innovation expenditure. This result seems logical as possibility of additional financial investment could support the firm and cause development of innovation. Moreover, public funding could be considered as private funding replacement. This result is similar with previous studies (Robin and Mairesse (2008)), but even larger in case of Estonia.

Table 4. Innovation expenditure and intensity to innovate equations

Independent variables	Innovation expenditure (0\1)			Innovation intensity		
	Total sample	Manufacturing sector	Service sector	Total sample	Manufacturing sector	Service sector
Foreignfirm	0.094	0.034	0.231	-0.279	-0.599	0.636
	(1.42)	(0.40)	(2.09)**	(-0.80)	(-1.42)	(1.00)
Internationalcompetition	0.287	0.579	0.114	1.267	0.476	1.242
	(2.97)***	(3.55)***	(0.91)	(2.20)**	(0.51)	(1.63)
Publicfunding	1.959	1.907	2.153	3.536	2.969	4.573
	(20.53)***	(16.79)***	(10.07)***	(5.61)***	(4.10)***	(3.74)***
Firmsize	0.302	0.324	0.286	0.082	0.089	0.076
	(9.60)***	(7.91)***	(5.33)***	(9.56)***	(7.93)***	(5.25)***
New managers from firms with process innovation	0.143	0.114	0.108	0.986	1.118	0.659
	(2.21)**	(1.36)	(0.99)	(3.13)***	(2.93)***	(1.18)
New managers from firms with product innovation	0.081	0.044	0.040	0.930	1.173	0.379
	(1.24)	(0.52)	(0.36)	(3.01)***	(3.13)***	(0.69)
Engaged in innovation cooperation				0.379	0.373	0.645
				(1.33)	(1.07)	(1.23)
Sources of information:						
Competitors				0.210	0.263	0.238
				(1.33)	(1.34)	(0.88)
Customers				-0.708	-0.914	-0.240
				(-4.72)***	(-5.12)***	(-0.85)
Suppliers				0.454	0.445	0.579
				(3.19)***	(2.53)**	(2.28)**
Number of observations	2615.000	1569.000	929.000	2615.000	1569.000	929.000
Log-likelihood	-3727.802	-2327.094	-1237.732	-3727.802	-2327.094	-1237.732

Note: Absolute values of z statistics parentheses *significant at 10%; ** significant at 5%; *** significant at 1%. Industry dummies have been included in all regressions.

It can also be noted that for innovation intensity different sources of information have ambiguous effect (Dachs et al.2008, for innovation process see Ukrainski and Varblane 2006). If the information about innovations comes from customers or suppliers than firms probably find it useful for innovation. Thus, these variables have positive and significant impact on innovation intensity. But from the other hand if the firm receives information from its competitors, the impact is not significant. This may be due to the lack of information flow between competitors.

The most significant for the purpose of this study is to investigate the impact of employees' mobility with different work experience in innovative sending firms on both innovation expenditure and intensity to innovate of receiving firm. If new manager comes from firm with process or product innovation to manufacturing sector then the innovation intensity increases. In this case labour mobility could be considered as a source of knowledge spillover and, thus, increase in knowledge stock influences positively on innovation input. But from the other side the arrival of the new manager from a different 2-digit industry has insignificant result in case of both manufacturing and service sectors. Thus, basically innovation expenditure of the receiving firm is not affected by labour mobility of the employee from different sector. This can be explained by the fact that the new employee does not know the specifics of the sector and therefore cannot apply his or her knowledge. Moreover, the knowledge of the worker is partly industry specific and, thus, could not be applied in other sector.

Results from the bivariate probit regressions on the second stage for both product and process innovations are presented in Table 5.The main findings are the following.

First of all, significant result for having product innovation in both manufacturing and service sectors is related to the source of information that firm receives from others within the group or within the firm. And the signs of coefficients are expected, similar result was obtained for Norway (Lööf et al. 2006). But for process innovation this variable has no effect. But if probability of process innovation is under consideration then such source of information as suppliers has positive and significant result on the innovation propensity in the overall sample.

Table 5. Probability of process and product innovation (Bivariate probit model)

Independent variables	Pr (Product innovation)			Pr (Process innovation)		
	Total sample	Manufacturing sector	Service sector	Total sample	Manufacturing sector	Service sector
New managers from firms with product innovation	-0.087 (-1.11)	-0.148 (-1.43)	0.048 (0.36)	0.273 (3.41)***	0.254 (2.36)**	0.263 (1.94)*
International competition	-0.207 (-1.65)*	-0.164 (-0.82)	-0.199 (-1.04)	-0.072 (-0.55)	0.082 (0.42)	-0.418 (-2.06)**
Foreign firm	0.061 (0.73)	0.076 (0.70)	0.034 (0.24)	0.152 (1.76)*	0.246 (2.15)**	0.096 (0.65)
Sources within the firm or other firms	0.228 (6.27)***	0.180 (3.81)***	0.318 (4.96)***	-0.027 (-0.74)	-0.055 (-1.11)	0.072 (1.13)
Competitors	0.026 (0.62)	-0.048 (-0.86)	0.195 (2.77)***	-0.081 (-1.89)*	-0.076 (-1.33)	-0.075 (-1.04)
Customers	0.256 (6.17)***	0.338 (5.92)***	0.108 (1.50)	0.030 (0.70)	0.023 (0.40)	0.006 (0.09)
Suppliers	-0.166 (-4.49)***	-0.240 (-4.98)***	-0.125 (-1.87)*	0.373 (9.89)***	0.454 (8.96)***	0.307 (4.51)***
Innovation expenditure (predicted)	0.091 (4.10)***	0.084 (2.64)***	0.138 (4.02)***	0.022 (0.97)	0.015 (0.46)	0.017 (0.51)
New managers from firms with process innovation	0.131 (1.67)*	0.233 (2.22)**	0.032 (0.24)	0.350 (4.37)***	0.394 (3.64)***	0.296 (2.20)**
Number of observations	1443.000	884.000	448.000	1443.000	884.000	448.000
Log-likelihood	-1651.691	-995.136	-508.481	-1651.691	-995.136	-508.481

Note: Absolute values of z statistics parentheses *significant at 10%; ** significant at 5%; *** significant at 1%. Industry dummies have been included in all regressions.

Secondly, for process innovation in manufacturing sector one of the most important factors is foreign firm ownership that increases the probability of having innovation, but it is insignificant for product innovation. Foreign ownership could be considered as knowledge spillover as the owner obtains the skills unknown in local market. Müller and Peters (2010) find that process innovation require more firm specific knowledge than product innovation. Thus, having this knowledge embodied in foreign owner firm could use it.

Thirdly, labour mobility seems to have different impact for different kinds of technological innovation. For example, the mobility of managers from sending firms that have experience in product innovation is not significant for product innovation but with process innovation it has positive and significant linkage result in the total sample. It could be explained by the fact that product innovations vary across different firms and having knowledge for developing new product does not mean the possibility of application the same skills in different product innovation. Thus, the worker should have specific knowledge for it.

For these results as it was already pointed it was used the information from the waves of Community Innovation Survey. It is held only among innovative firms that are larger than 10 employees. Thus, the obtained results for labour mobility do not include the mobility of workers who came from small firms that were not included in survey. This fact could affect on the results and cause to the underestimation. But in case of Estonia the degree of underestimation is quite low as large firms are covered. Moreover, the measure of flow for new employees is not significant for both sample selection equation and bivariate probit model (see Appendix 4).

5. Conclusion

This study has investigated the linkages between labour mobility and the innovation activities at the firm level. In developing the hypothesis I explore the existing literature and find that in most of the studies the positive effect of labour mobility on innovations has been found. This research is based on several fundamental theories of labour mobility, as well as several articles on labour mobility as the source of knowledge spillovers. The most significant for this study were the articles that substantiated the channels of influence of labour mobility on the company's innovation activities. Thus, it was found that labour mobility increases inputs for innovations, thus, increases the probability of implementing new product or process into the market. Thus for the empirical analysis I came up with the research proposition that the linkage of the labour mobility and innovation activities is positive. In empirical analysis I apply CDM model and distinguish between process and product. In the 2^{nd} stage of the CDM model it was estimated the equations for product and process innovation jointly using bivariate model. Our hypothesis of a positive effect of labour mobility on probability of having innovation are not fully reflected by the results of the empirical investigations.

We find that the specialization of the sending firm matters. If the manager moves from firms that has product or process innovation experience then it has positive impact only for process innovation. But for having positive result on probability of product innovation the sending firm of the employee should have process innovation experience.

Appendix 1. Description of the main variables

Variable	**Description**
Process innovation (dummy)	New or significantly improved production process, introduced by the firm in 2008-2010 or 2010-2012
Product innovation (dummy)	New or significantly improved products, introduced by the firm in 2008-2010 or 2010-2012
Foreign firm	Foreign firm ownership. Dummy, 1 if there is foreign firm participation in ownership
Public funding	Public funding for innovations. Dummy, 1 if firm receives public funding for innovations
International competition	Participation of the firm in international market. Dummy, 1 if firm compete in the international market
Lack of apppriate sources of finance	Obstacle for innovation activities made up lack of financial support. Dummy, 1 if lack of finance was at least of medium importance
Lack of information on markets	Obstacle for innovation activities made up lack of information about market. Dummy, 1 if lack of information was at least of medium importance
Lack of qualified personnel	Obstacle for innovation activities made up lack of qualified employees. Dummy, 1 if lack of personnel was at least of medium importance
Lack of information on technology	Obstacle for innovation activities made up lack of information about obtained technology for innovation project. Dummy, 1 if lack of information about technology was at least of medium importance
Engaged in innovation cooperation	Involvement in partnership for innovation development. Dummy, 1 if the firm has any partner
Customers	Important information about innovation project comes from customers or clients. Dummy, 1 if the firm has information from customers or clients
Competitors	Information about innovation project comes from competitors. Dummy, 1 if the firm has information of high importance from competitors
Sources within the firm or other firms within the group	Important information about innovation project comes from other group of firms. Dummy, 1 if the firm has information of high importance from other firms
Suppliers	Cooperation of the firm in innovation activities with its suppliers. Dummy, 1 if there is a cooperation with suppliers

Appendix 2. Descriptive statistics of the main variables

Variable	**Mean**	**St. Dev.**	**No. Of obs.**
Dependant variables			
Process innovation (dummy)	0.341	0.474	11543
Product innovation (dummy)	0.304	0.46	11543
Independent variables			
Public funding	0.0718	0.256	13606
International competition	0.588	0.492	13280
Innovation cost too high	0.206	0.404	13606
Lack of apppriate sources of finance	0.235	0.424	13606
Lack of apppriate sources of finance within the firm	0.166	0.372	9832
Lack of information on markets	0.112	0.315	13606
Lack of qualified personnel	0.191	0.393	13606
Lack of indormation on technology	0.108	0.311	13606
Engaged in innovation cooperation	0.189	0.391	13606
Firm size	2.886	1.248	63634
Customers	1.497	1.062	5830
Competitors	1.187	0.997	5830
Sources within the firm or other firms within the group	1.771	1.061	5830
Suppliers	1.672	1.088	5830
Number of employees	41.526	181.605	71655

Appendix 3. Estimation in CDM of variable Share of managers and employees

Independent variable	**Heckman equation**	**Biprobit equation**
Share of managers from firms with product innovation	3.142	1.116
	(0.69)	(1.41)
Share of new employees from operating firms	0.072	-0.387
	(1.06)	(-0.87)
Share of managers from firms with process innovation	-1.306	0.036
	(-0.52)	(1.18)
Sq. share of managers from firms with product innovation	-10.986	1.188
	(-1.59)	(0.55)
Sq. share of new employees from operating firms	-10.758	0.232
	(-3.07)***	(0.24)
Sq. share of managers from firms with process innovation	-5.040	0.037
	(-1.35)	(1.18)

Note: Note: Absolute values of z statistics parentheses *significant at 10%; ** significant at 5%; *** significant at 1%

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